

Chapter 4: Compliance Through Quality Construction

4.0 SUMMARY

This chapter introduces the new features for the 1998 Energy Efficiency Standards (standards) that award compliance credit for improvements in the quality of design and installation of ducts and of construction of less leaky building envelopes. These new features include improved computer modeling methods and new compliance credit options. Many of the compliance credit options require installer diagnostic testing and certification, and independent diagnostic testing and field verification by a certified Home Energy Rater.

This chapter also brings attention to the *Procedures for HVAC System Design and Installation* given in Appendix K. These procedures comprehensively address all aspects of quality installation of HVAC equipment and duct systems. These procedures are intended to produce duct systems that are well designed, installed and performance tested to verify their effectiveness in delivering comfort and energy efficiency to home occupants. By following these procedures and the complementary compliance requirements, substantial compliance credit can be earned for reduced duct leakage, ACCA Manual D design, and possibly reduced duct surface area.

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4.1 DUCT EFFICIENCY

A. Overview

For the 1998 standards, the Commission has approved new algorithms and procedures for determining duct efficiency, and has created new options for compliance credit for improvements that can be made that will increase duct efficiency. Duct efficiency can be impacted by the following parameters

1. The location of the duct system (attic, crawlspace, basement or other).
2. The installation of the duct system inside conditioned space.
3. The installation of a radiant barrier in attics with ducts.
4. The insulation level of the ducts.
5. The surface area of the ducts.
6. The air leakage level of the duct system.
7. The design of the duct system to ACCA Manual D.

There are two calculation procedures to determine seasonal air distribution efficiency using either (1) default input assumptions or (2) diagnostic measurement values (see also Part 4.3). The computer program will use default assumptions for the proposed design when the user does not intend to make improvements in duct efficiency. For low-rise, single-family buildings compliance credit can be taken for proposed designs that make any duct efficiency improvement. For dwellings other than low-rise, single-family buildings compliance credit can be taken for increased duct insulation only. The program otherwise will use default assumptions for all proposed designs of dwellings that are not low-rise, single-family dwellings.

Compliance credit for many of the duct efficiency improvements require diagnostic testing and verification by a Commission approved HERS provider/rater (see section 4.3 for Diagnostics and Field Verification procedures and requirements). Required methods for conducting diagnostic testing and field verification for duct efficiency improvements are described in detail in *Appendix F* of the *Alternative Calculation Method Approval*

Manual which is included in the *Residential Energy Conservation Manual* as Appendix J.

Compliance credit can not be taken for any duct efficiency improvement unless the duct system is a fully ducted system. Duct efficiency credits may not be taken for any system that uses building cavities such as plenums or platform returns.

Also, when any duct efficiency credit is claimed, the duct connections and leaks shall not be sealed with cloth back rubber adhesive tapes (i.e., duct tapes) unless such tape is used in combination with mastic and drawbands. This requirement must be specified in the HERS Required Verification listings on the CF-1R and the CF-2R.

When more than one HVAC system serves the building or dwelling, the duct efficiency is determined for each system based on the improvements made to the each duct system, and a conditioned floor area-weighted average of the efficiencies of each separate system is determined.

B. Duct Location

Where ducts are installed has a significant effect on the efficiency of distributing heated or cooled air. Therefore, the location of ducts affects the way the program models the overall efficiency of space conditioning equipment. Ducts are typically installed in attics. This is the location that results in the greatest energy loss. This is the default location for compliance purposes. Ducts located in crawlspaces, basements or in conditioned space can be significantly more efficient. Ducts in other spaces (i.e., not in crawlspaces, basements or in conditioned space; e.g., in garages) are assumed to perform the same as ducts in attics. When compliance credit is being taken for improved duct location, the installer must certify on the CF-6R that the ducts are installed in that location.

A default compliance credit for ducts located in crawlspaces or basements may be approved by the local enforcement agency without HERS rater verification. The default assumptions for ducts installed in crawl-

spaces or basements apply only to buildings with all supply ducts installed in the crawl-space or basement. A duct layout must be included in the plans that show that all of the supply registers are located in the floor. If any story of a building has any supply registers located more than two feet above the floor, the duct location for that story must be modeled as 100% in the attic. The computer program will automatically specify that all supply registers for each story are located in the floor in the *Special Features and Modeling Assumptions* listing to aid the local enforcement agency's inspections.

Proposed duct systems with a complete ACCA Manual D design, including the duct layout and design on the plans, may allocate duct surface areas in more detail in the computer program. The distribution of duct surface areas by location must appear on the *HERS Required Verification* list for verification by an approved HERS rater.

C. Ducts Inside Conditioned Space

Credit is given when most or all of the ducts of a ducted HVAC system are installed inside conditioned space. Credit can be taken for ducts inside the conditioned space for two situations: 1) Less than 12 lineal feet of ducts within unconditioned space; and 2) all ducts (and the air handler) within the conditioned space. The first situation would typically apply to a ducted furnace or heat pump inside a garage with a relatively short duct run from the air handler to the conditioned space.

Compliance credit can also be taken for duct systems where all ducts including the air handler are installed inside conditioned space. Ducted, central gas furnaces installed in this manner will need to have provisions for supplying outdoor air for combustion and combustion product venting without using draft relief openings. These ducts in conditioned space options must be specified on the *HERS Required Verification* list for verification by an approved HERS rater.

Non-central gas furnaces [those listed in Table G-1 of Appendix G in this manual] such as wall furnaces are compared to a *Standard*

Design using a non-central gas furnace with no ducts and the minimum allowed efficiency for the type of furnace used in the *Proposed Design*. Similarly, non-central air conditioners [those listed in Table G-3 of Appendix G of this manual] are compared to a similar non-central air conditioner without ducts in the *Standard Design*. Other systems, such as hydronic heating systems with a central heater or boiler and multiple terminal units, are considered central HVAC systems that are compared to a ducted system in the *Standard Design* and may receive compliance credit for "less than 12 lineal feet of ducts in conditioned space." Electric baseboard heating systems may be modeled as "all ducts in conditioned space."

D. Ducts in Attics with Radiant Barriers

Installation of a radiant barrier in the attic increases the duct efficiency by lowering attic summer temperatures. Compliance credit for radiant barriers requires listing of the radiant barrier in the *Special Features and Modeling Assumptions* listings to aid the local enforcement agency's inspections. Compliance credit for a radiant barrier does not require HERS rater verification.

E. Duct R-Value

The R-value of duct insulation is specified for ducts in unconditioned space. R-4.2 is a mandatory feature and is the default R-value. Compliance credit can be taken for additional duct insulation. If ducts with multiple R-values are installed, the lowest duct R-value shall be used for the entire duct system. In some cases the space on top of the duct boot is limited and can not be inspected. For this reason, the insulation R-value within two feet of the boot may be excluded from the determination of the overall system R-value. When the modeled R-value is greater than 4.2, the computer program must report the specified R-value in the *Special Features and Modeling Assumptions* listing to aid the local enforcement agency's inspections. Compliance

credit for Increased duct insulation does not require HERS rater verification.

F. Duct Surface Area

The default values for duct surface areas outside of conditioned space are 27% of conditioned floor area (CFA) for supply duct surface area; 5% of CFA for return duct surface area in single story dwellings and 10% of CFA for return duct surface area in dwellings with two or more stories. Compliance credit can be taken for proposed designs with reduced duct surface areas outside of conditioned space. The proposed design can specify field measured reduced duct surface area. If compliance credit is taken for reduced surface area, the installer must certify the installed surface area on the CF-6R.

Reduced duct surface areas must be shown to preserve adequate airflow to receive duct efficiency credit. Consequently, compliance credit for measured reduced duct surface area can only be taken in conjunction with ducts, which are designed to conform to ACCA manual D (including duct layout and design specifications on the plans). The total specified measured surface area and its subcomponent allocation by duct location must be in the *HERS Required Verification* listing, and be verified by a certified HERS rater. Credit for measured reduced duct surface area also requires that the HERS rater verify the consistency of the actual duct system with the ACCA Manual D design as specified in section H below.

G. Duct Leakage

The default duct air leakage is set at 22% of fan flow. Compliance credit can be taken for reduced duct leakage if duct leakage is diagnostically measured and verified to be less than 6% of fan flow.

The target duct leakage is determined as a percentage of the installed system capacity or from default calculations as a percentage of the conditioned floor area when the HVAC equipment is not installed at the time of testing by the duct installer. If the HVAC system

is installed at the time of installer testing, the leakage target is 6% of the supply fan capacity, calculated as 400 CFM per ton of air conditioning or 21.7 CFM per 1,000 Btu/hour of furnace capacity, whichever is larger. If the HVAC equipment is installed but the size is not known at the time of installer testing, the leakage target is 6% of 0.70 CFM per square foot of conditioned floor area for climate zones 8 to 15 and 0.50 CFM per square foot of conditioned floor area for the remaining climate zones.

If the HVAC equipment is not installed at the time of installer testing, the leakage target is 4% of 0.70 CFM per square foot of conditioned floor area for climate zones 8 to 15 and 0.50 CFM per square foot of conditioned floor area for the remaining climate zones.

In addition to installer leakage testing and certification, compliance credit for duct leakage reduction requires diagnostic testing and verification by a certified HERS rater. The *HERS Required Verification* listing and the CF-6R must specify the target duct leakage(s) for verification by the HERS rater.

H. ACCA Manual D Design -- Duct Layout and System Fan Flow

The default condition assumes that the duct system has not been designed to meet ACCA manual D. Compliance credit can be taken if the duct system is designed to meet ACCA manual D, and a duct layout, engineering calculations, and duct system specifications are in the plans. The plans must specify either the system fan flow determined by the ACCA manual D design or the installation of a thermostatic expansion valve. The installation of a thermostatic expansion valve must be verifiable through installation of a removable access panel on the cooling coil.

Compliance credit for ACCA manual D design requires diagnostic testing and verification by an approved HERS rater. The system fan flow or the installation of a thermostatic expansion valve must be specified on the *HERS Required Verification* listing. The HERS rater must verify the existence of the ACCA man-

ual D design, specifications and layout, and verify the consistency of the actual HVAC distribution system with the design. This consistency check includes verifying that space-by-space load and supply air calculations were done for each space, that duct runs are no longer than the design, that the ducts are not compressed or constricted, and that duct sizes and insulation R-values match the design. The HERS rater also must either 1) diagnostically test the system fan flow and verify that the fan flow specified by the ACCA manual D design is achieved or 2) remove the access panel and verify the installation of the thermostatic expansion valve.

4.2 INFILTRATION & VENTILATION

A. Overview

For the 1998 standards, the Commission has approved new algorithms for infiltration and ventilation, and has created new options and procedures for compliance for reduced building envelope air leakage. The replacement of conditioned indoor air by unconditioned outdoor air creates heat gains and heat losses for a conditioned building. Infiltration is the unintentional replacement of conditioned air with unconditioned air through leaks or cracks in the building envelope. Ventilation is the intentional replacement of conditioned air with unconditioned air through opening windows or mechanical ventilation.

Ventilation in residential buildings is typically achieved by opening windows either to provide natural ventilation for cooling purposes or to reduce stuffiness or odors. The use of continuous mechanical ventilation provides a greater degree of control of the rate of exchange of conditioned and unconditioned air. Continuous mechanical ventilation can be provided through either supply fans or exhaust fans. Providing **supply** fan ventilation is also a means to avoid building depressurization, which otherwise can lead to backdrafting of combustion appliances in “unusually tight” buildings.

Reduction in building envelope air leakage decreases infiltration and can result in signifi-

cant energy savings especially in climates with more severe winter and summer conditions. It also can result in improved building comfort, reduced moisture intrusion, and can avoid introduction of air pollutants due to leakage from garages or attics.

B. Indoor Air Quality

ASHRAE Standard 62-89 *Ventilation for Acceptable Indoor Air Quality* specifies a minimum effective annual air exchange rate. This minimum rate is the combination of infiltration, ventilation through window opening and continuous mechanical ventilation if supplied. For typical California homes infiltration is excessive and the ASHRAE 62 standard is met or exceeded with occasional window opening. As building envelope leakage is reduced, the frequency for when windows need to be opened slightly to relieve stuffiness, remove odors and provide indoor air quality increases.

C. Optimal Building Envelope Leakage

From an energy standpoint there is an optimal level of reduced building envelope air leakage if additional ventilation is provided through opening windows alone. Below that optimal building envelope air leakage, the energy penalty of increased frequency of window opening exceeds the energy savings of the reduction in infiltration. If building envelope leakage is reduced substantially below the optimal energy savings level, a level that the Commission considers to be “unusually tight” per the Uniform Mechanical Code can be reached where it is necessary to provide continuous mechanical supply ventilation.

D. New Algorithms

The new algorithms approved by the Commission keep track of the combination of infiltration, ventilation through opening windows, and continuous mechanical ventilation, if any, to model conformance with the ASHRAE 62 standard and determine the energy consequences. Approved computer programs can be used to determine optimal building enve-

lope leakage levels that can be specified for compliance purposes.

Approved computer programs use a default building envelope air leakage (expressed in terms of Specific Leakage Area, SLA) for proposed designs when the user does not intend to take compliance credit for building envelope sealing. The default is set at 4.9 SLA. Careful attention to building envelope sealing would result in significantly lower SLA levels.

E. Blower Door Testing

Compliance credit can be taken for reduced building envelope leakage verified through diagnostic blowerdoor testing as specified by ASTM E-779-87, *Standard Test Method for Determining Air Leakage Rate by Fan Pressurization*. Users of approved computer programs can determine the compliance credit available for specific SLA levels (or target blowerdoor test results). The program will automatically convert that SLA level to the target CFM50_H required for the blowerdoor testing to achieve the modeled SLA, and specify that target CFM50_H level in the *HERS Required Verification* listing on the CF-1R and C-2R. The installer must do testing to demonstrate that building envelope leakage has been reduced below the target CFM50_H level, and document the blowerdoor test results on the CF-6R. An approved HERS rater must do blowerdoor testing to verify that the target CFM50_H has been achieved (see section 4.3 for Diagnostics and Field Verification procedures and requirements).

F. Mechanical Supply Ventilation Requirements for Unusually Tight Buildings

The program will also report in the *HERS Required Verification* section the minimum allowed CFM50_H (corresponding to an SLA of 1.5) unless continuous mechanical **supply** ventilation is installed. This minimum allowed value without continuous mechanical supply ventilation is considered by the Commission to be “unusually tight” per the requirements of the Uniform Mechanical Code.

The *HERS Required Verification* section of the CF-1R must state that when the minimum blowerdoor testing reveals that the CFM50_H is less than the minimum allowed value, corrective action must be taken either to intentionally increase the infiltration or provide for continuous mechanical **supply** ventilation adequate to maintain the residence at a pressure greater than -5 Pascal relative to the outside air pressure with other continuous ventilation fans operating. Blowerdoor testing must be done by both the installer and the HERS rater to verify compliance with these requirements.

The total power consumption of the continuous supply ventilation fans and continuous exhaust fans are required inputs when compliance credit is taken for reduced building envelope leakage and mechanical ventilation is installed.

G. Mechanical Ventilation Requirements for Low Leakage Designs

When the user of compliance programs chooses the proposed design envelope leakage to be below 3.0 SLA, continuous mechanical ventilation (either exhaust or supply ventilation) must be installed. Whenever continuous mechanical ventilation is installed, a minimum capacity of 0.047 CFM per square foot of conditioned floor area is required. This requirement for installation of continuous mechanical ventilation is reported automatically by the program in the *HERS Required Verification* section of the CF-1R and C-2R. The installer and the HERS rater must confirm compliance with these requirements.

When reduced building envelope leakage or continuous mechanical ventilation is specified for compliance, the computer program will automatically include in the *Special Features and Modeling Assumptions* section a statement that the homeowner's manual provided by the builder to the homeowner must include instructions that describe how to use the operable windows or continuous mechanical ventilation for proper ventilation.

The total power consumption of the continuous supply ventilation fans and continuous exhaust fans are required inputs when compliance credit is taken for reduced building envelope leakage and mechanical ventilation is installed.

H. Envelope Leakage Credit for Reduced Duct Leakage

If compliance credit is **not** taken for reduced building envelope air leakage through diagnostic testing, a special “default” compliance credit can be taken for building envelope leakage reduction resulting from reduced duct leakage. To qualify for this credit all requirements of section 4.4.14 *Duct Leakage* must be met. A “default” reduction in Specific Leakage Area of 0.50 is allowed for this credit.

I. Air Retarding Wrap Credit

If compliance credit is **not** taken for reduced building envelope air leakage through diagnostic testing, a special “default” compliance credit can be taken for building envelope leakage reduction resulting from installation of an air retarding wrap (i.e., housewrap). To qualify for the “default” compliance credit, an air retarding wrap must be tested and labeled by the manufacturer to comply with ASTM E1677-95, *Standard Specification for an Air Retarder (AR) Material or System for Low-Rise Framed Building Walls*, and have a minimum perm rating of 10. Insulative sheathing and building paper do not qualify as air retarding wraps.

The air-retarding wrap must be installed per the manufacturer's specifications that must be provided to comply with ASTM E1677-95. In particular, the air-retarding wrap must meet the following installation requirements:

- The air retarding wrap must be applied continuously;
- All tears or breaks must be repaired with manufacturer approved tape.
- All horizontal seams must be lapped in a shingle-like manner and taped.
- All vertical seams must be lapped and.

- All windows and penetrations must be taped or caulked.
- The air-retarding wrap must be taped or otherwise sealed at the slab junction.

When compliance credit is taken for an air-retarding wrap, the computer program will automatically include the air retarding wrap and the above specifications in the *Special Features and Modeling Assumptions* section of the CF-1R and C-2 to facilitate inspection by the local enforcement agency. Compliance credit for an air retarding wrap does not require HERS rater verification.

Compliance credit is provided for a “default” reduction in Specific Leakage Area of 0.50.

J. Envelope Leakage Credit for Reduced Duct Leakage in Combination with Air Retarding Wrap

The default credits in **G** and **H** may be added when both measures are installed and the criteria in **G** and **H** are both met.

4.3 DIAGNOSTICS AND FIELDVERIFICATION

A. Overview

The new algorithms and credits for reduced building envelope leakage and for improved HVAC distribution (duct) efficiency require special enforcement procedures. All credits for improved efficiency for these measures are listed either in the *Special Features and Modeling Assumptions* listings or the *HERS Required Verification listings* of the CF-1R Certificate of Compliance Form and the CF-2 Form. The information on the CF-1R, including these listings, is required to be on the plans. In addition, the CF-4 Form and some of the information on the CF-6R, Installation Certificate document the qualifications for the use of these energy credits.

The information that is only in the *Special Features and Modeling Assumptions* listings,

such as credit for air retarding wraps or duct insulation above R=4.2, is verified by the local enforcement agency. Information found in the *HERS Required Verification* must be verified by a HERS rater certified by a Commission-approved HERS provider.

B. California Home Energy Rating Systems

The Commission approves home energy rating system (HERS) providers in California who conform with *California HERS* regulations (Title 20, Chapter 4, Article 8, Sections 1670-1676). Approved HERS providers are authorized to certify raters and maintain quality control over ratings. Ratings are based on visual inspection and diagnostic testing of the physical characteristics and energy efficiency features of houses, as constructed.

When compliance documentation indicates field verification and diagnostic testing of specific energy efficiency improvements as a condition for those improvements to qualify for Title 24 compliance credit, an approved HERS provider and certified rater must be used to conduct the field verification and diagnostic testing. HERS providers and raters are considered special inspectors by building departments, and must demonstrate competence, to the satisfaction of the building official, for the visual inspections and diagnostic testing. The HERS provider and rater must be independent entities from the builder or subcontractor installer of the energy efficiency improvements being tested and verified, and can have no financial interest in the installation of the improvements. The procedures for HERS required field verification and diagnostic testing are specified in this chapter and in the *Alternative Calculation Method Approval Manual*.

Duct Efficiency Improvements and Building Envelope Air Sealing that Require HERS Verification and Testing are:

Duct Efficiency Improvements

- Duct sealing (duct leakage testing)
- Duct design (ACCA Manual D verification and fan flow testing)

- Duct location (verification)
- Duct surface area (verification)

Building envelope Air Sealing using diagnostic blowerdoor testing—includes reduced infiltration and continuous mechanical ventilation installation

Duct Efficiency Improvements and Building Envelope Air Sealing that Do Not Require HERS Verification and Testing, Only Building Department Inspection are:

- Duct insulation
- Radiant barriers
- Supply duct location in crawlspaces or basements when all supply registers are in the floor (default compliance credit)
- Building envelope air sealing associated with duct sealing (default compliance credit)
- Building envelope air sealing associated with air retarding wrap installation (default compliance credit)

C. HERS Required Verification and Diagnostic Testing

Calculation of the energy consumption associated with increased duct efficiency and reduced building envelope leakage requires a computer compliance method. Improvements in duct efficiency resulting from duct air sealing, ACCA Manual D design and installation, and building envelope sealing beyond improvements covered by default assumptions, require diagnostic testing and field verification. Improvements in duct efficiency resulting from duct surface area reductions and duct location improvements beyond those covered by default assumptions require field verification. For compliance credit to be claimed for these features, they must be listed as *HERS Verification Required* features on the *Certificate of Compliance* (CF-1R) and the *Computer Method Summary* (C-2R). Such verification constitutes “eligibility and installation criteria” for these features. Diagnostic testing and field verification shall be per-

formed as specified in Chapters 3 and 4, and Appendix F of the *Alternative Calculation Method Approval Manual* (also included in the *Residential Energy Conservation Manual* as Appendix J)

D. Installer Certification

When compliance credit is claimed for duct sealing, ACCA Manual D design and installation, or envelope sealing, builder employees or subcontractors must

- complete diagnostic testing, and
- certify the diagnostic test results and that the work meets the requirements for compliance credit on the CF-6R.

For duct sealing completed at the rough-in stage of construction using aerosol sealant closures, builder employees or subcontractors must:

- at rough-in, complete the fan pressurization test and certify on the CF-6R the diagnostic results,
- after installation of the interior finishing wall, verify sealing of the ducts using either the house pressure test or the pressure pan test or by visual inspection of all duct connections (including duct to air handler connections), and
- certify on the CF-6R the diagnostic results and that the work meets the requirements for compliance credit.

When compliance credit is claimed for duct surface area reductions and duct location improvements beyond those covered by default assumptions, builder employees or subcontractors must

- record on the CF-6R the duct surface area in each duct location, and
- certify on the CF-6R that the duct surface area and locations match those on the plans, and that the work meets the requirements for compliance credit. Installer certifications are required for each and every house.

E. Sampling Procedures

At the builder's option HERS field verification and diagnostic testing shall be completed either for each house or for a sample of houses of the same model. To be considered the same model, houses shall be in the same subdivision and have the same energy designs and features, including the same floor area and volume, as shown on the CF-1R except that a house may differ in its shading.

Field verification and diagnostic testing for compliance credit for duct sealing must use the diagnostic duct leakage from fan pressurization of the ducts (see section 4.3.8.2.1 of *Appendix F* of the *Alternative Calculation Method Approval Manual* -- *Appendix J* of the *Residential Energy Conservation Manual*).

The builder must provide the HERS provider a copy of the CF-6R containing the installer certifications. Prior to completing field verification and diagnostic testing, the HERS rater must first verify that the installer certifications have been completed.

If the builder chooses the sampling option, the procedures described in this section shall be followed.

Initial Field Verification and Testing

Initial testing allows the builder to identify and correct any potential construction flaws or practices in the build out of each model.

The HERS rater must diagnostically test and field verify the first house of each model. If field verification and diagnostic testing determines that the requirements for compliance are met, the HERS rater will provide a signed and dated *Certificate of Field Verification and Diagnostic Testing* (CF-4R) for that house to the builder and the HERS provider.

Sample Field Verification and Testing

After the initial testing is complete, the builder must identify a group of houses of the same model from which a sample will be selected for testing, and notify the HERS provider. The group of houses must include those houses expected to be ready for diag-

nostic testing within a 180-day period. The builder must identify these houses by location of County, City and either the street address or the subdivision and lot number, and the names and license numbers of subcontractors responsible for the duct installation, duct sealing or envelope sealing that requires diagnostic testing or field verification. The builder may add additional houses during the 180-day period by notifying the HERS provider.

The HERS provider must select a minimum of one out of every seven sequentially completed houses in the group, rounded up to the next whole number, for diagnostic testing and field verification. When several houses are ready for testing at the same time, the HERS provider must randomly select the houses to be tested. The HERS rater must diagnostically test and field verify the houses selected by the HERS provider.

If field verification and diagnostic testing determines that the requirements for compliance are met, the HERS rater provides a signed and dated *Certificate of Field Verification and Diagnostic Testing* (CF-4R) to the builder and the HERS provider. The *Certificate* will report the successful diagnostic testing results and conclusions regarding compliance for the tested house.

The HERS rater must also provide a signed and dated *Certificate of Field Verification and Diagnostic Testing* to the builder and the HERS provider for up to six additional houses from the group. The *Certificate* must not be provided for houses in which the feature requiring field verification and diagnostic testing is not installed, sealed or completed.

The 180 day period officially begins on the date of the first *Certificate of Field Verification and Diagnostic Testing* for the group. The HERS provider must determine the date the 180 day period ends, and must notify the builder and rater. Houses within the group for which a *Certificate of Field Verification and Diagnostic Testing* is not complete within 180 days from the date of the first *Certificate* for the group, as determined by the HERS provider, shall either be individually tested or be included in a group of houses in a subsequent sample period.

Whenever the builder changes subcontractors responsible for the feature that is being diagnostically field verified and tested, the builder must notify the rater of any subcontractors who have changed, and terminate sampling for the identified group. The rater shall cease certification. Whenever the builder changes HERS providers, the builder shall terminate sampling.

All houses using *HERS Required Verification* features for compliance that were installed by previous subcontractors or were subject to verification and testing under the supervision of a previous HERS provider, for which the builder does not have a completed *Certificate of Field Verification and Diagnostic Testing* must either be individually tested or included in a new group for sampling. Houses with installations completed by new subcontractors must either be individually tested or be included in a new sampling group following a new *Initial Field Verification and Testing*.

The HERS provider must not notify the builder when sample testing is going to occur before the work to be tested is complete. After the builder is notified by the HERS provider as to when testing will occur, the builder cannot perform additional work on the features that will be tested.

Re-sampling, Full Testing and Corrective Action

When a failure is encountered during sample testing, the HERS rater must conduct re-sampling to assess whether the failure is unique or the rest of the houses are likely to have similar failings. The HERS provider must select for re-sampling one out of seven (rounded up to the next whole number) of all of the untested houses in the group that have been constructed since the beginning of the 180-day time period.

If testing in all houses in the re-sample confirms that the requirements for compliance credit are met, then the house with the failure is not considered an indication of failure in the other houses in the group. The builder must take corrective action for the house with the failure, and then the HERS rater must retest to verify compliance and issue a

signed and dated *Certificate of Field Verification and Diagnostic Testing* to the builder. Sampling shall then resume for the remainder of the group.

If field verification and testing in any of the houses in the re-sample results in a second failure, the builder must take corrective action in all unoccupied houses in the group that were not tested but for which a *Certificate of Field Verification and Diagnostic Testing* was completed. The HERS rater must conduct field verification and diagnostic testing in each of these houses to verify that problems have been corrected and that the requirements for compliance have been met, and must report to the HERS provider.

Builders must offer at no charge to homeowners in occupied houses in the group to complete field verification and testing and corrective action, if necessary. Homeowners may decline this offer. Builders must report the identifying location of any house in which the homeowner declines field verification and testing and corrective action to the HERS provider. The HERS provider must verify that the builder has made this offer. If a homeowner in an occupied house declines this offer, field verification, testing and corrective action will not be required for that house and the house will no longer be considered a part of the group. If a homeowner accepts this offer, the builder must take corrective action. The HERS rater must then conduct field verification and diagnostic testing to verify that problems have been corrected and that the requirements for compliance have been met, and shall report to the HERS provider.

The HERS provider must file a report with the building department explaining all action taken (including field verification, testing, corrective action, offers to homeowners for testing and corrective action, and homeowner declines of such offers) to bring into compliance houses for which a signed and dated *Certificate of Field Verification and Diagnostic Testing* has been provided to the builder. If corrective action requires work not specifically exempted by Section 112 of the UMC or Section 106 of the UBC, the builder must obtain a permit from the building department prior to commencement of any of the work.

Until corrections, field verification and testing of all houses in the group is complete, or homeowners in occupied houses have declined corrective action, houses in the group shall not be certified for compliance. If additional houses are completed during the time required to correct, field verify and test the previously completed houses in the group, the rater shall individually field verify and diagnostically test those additional houses to confirm that the requirements for compliance credit are met. Once corrections, field verification and testing is completed for all houses that have a *Certificate of Field Verification and Diagnostic Testing*, excepting those where homeowners have declined corrective action, the builder must either resume sampling for the remainder of the houses in the group or terminate the group.

If corrections are made to a sampled house to avoid a failure, corrections, field verification and testing shall be performed on 100% of the houses in the group that are constructed since the beginning of the 180-day sampling period.

F. Responsibilities and Documentation

Builder

Builder employees or sub-contractors performing work that requires HERS rater field verification and diagnostic testing shall certify on the CF-6R the diagnostic test results and that their work meets the requirements for compliance credit.

The builder shall also:

- (1) Furnish the HERS provider with the identifying location of the group of houses to be included in the sample for field verification and diagnostic testing and the expected date on which sample testing can begin;
- (2) Supply the HERS provider with a copy of the CF-6R signed by the builder employees or sub-contractors certifying that diagnostic testing and installation meet the requirements for compliance credit; and

- (3) Provide a *Certificate of Field Verification and Diagnostic Testing* signed and dated by the HERS rater to the building official in conjunction with requests for final inspection for each house

When resampling reveals a failure the builder shall:

- (1) Take corrective action as required in all unoccupied houses in the group and in occupied houses in the group where homeowners have accepted field verification, testing and corrective action.
- (2) Offer at no charge to homeowners of occupied houses in the group to complete field verification, testing and corrective action if necessary. Homeowners may decline to have field verification and testing and corrective action completed. Builders shall report the identifying location of any house in which the homeowner declines field verification and testing and corrective action to the HERS provider.

HERS Provider and Rater

For a period of 5 years from the date of the field verification and diagnostic testing of a group of houses, the HERS **providers** shall maintain a list of:

- Houses in the group from which sampling is drawn
- Houses selected for sampling
- Houses sampled
- Results of the sampling
- Houses selected for re-sampling
- Houses that were re-tested
- Corrective action taken
- Copies of all *Certificates of Field Verification and Diagnostic Testing*

The HERS **raters** providing the diagnostic testing and verification shall:

- Sign and date a *Certificate of Field Verification and Diagnostic Testing* certifying that they have verified that the requirements for compliance credit were met;

- Provide, for the tested house and up to six other houses from the group for which compliance is verified based on the results of the sample, a *Certificate of Field Verification and Diagnostic Testing* to the builder and the HERS provider;
- Provide a separate *Certificate of Field Verification and Diagnostic Testing* for each house the rater determines has met the diagnostic requirements for compliance;
- Identify on the *Certificate of Field Verification and Diagnostic Testing* if the house was tested or if it was an untested house approved as part of sample testing; and
- Not sign a *Certificate of Field Verification and Diagnostic Testing* for a house that does not have a CF-6R signed by the installer as required in 5.7B and D.

If field verification and testing on a sampled house identifies a failure to meet the requirements for compliance credit, the HERS **rater** shall report to the HERS provider and the builder that re-sampling will be required. If re-sampling identifies another failure, the HERS rater shall report to the HERS provider and the builder that corrective action and full testing will be required for all the untested houses in the group that have been constructed since the beginning of the 180-day period. This report shall specify the identifying location of all houses that must be corrected and fully tested.

The HERS **provider** shall also report to the builder once diagnostic testing and field verification has shown that the failures are corrected in all of the houses except those for which the homeowner has declined field verification, testing and corrective action.

When individual house testing and verification confirms that the requirements for compliance were met, the HERS **rater** shall provide a *Certificate of Field Verification and Diagnostic Testing* for each previously untested/unverified house in the group and for each additional house of the same model completed during the time required to correct,

verify and test the previously untested/unverified houses in the group.

The HERS **provider** shall report to the building department explaining all action taking (including field verification, testing, corrective actions, offers to homeowners for testing and corrective action, and homeowner declines for testing, verification and corrective action) to bring into compliance houses for which a signed and dated *Certificate of Field Verification and Diagnostic Testing* has been provided to the builder.

Building Department

The building department at its discretion may require independent testing and field verification in conjunction with the building department's required inspections, and/or observe the diagnostic testing and field verification performed by builder employees or subcontractors and the certified HERS rater in conjunction with the building department's required inspections to corroborate the results documented on installer certifications, and in the *Certificate of Field Verification and Diagnostic Testing*. For houses that have used a compliance alternative that requires field verification and diagnostic testing, the building department shall not approve a house for occupancy until the building department has received from the builder a *Certificate of Field Verification and Diagnostic Testing* signed and dated by the HERS rater. The building department at its discretion may request that the HERS provider report failures, corrective actions, need for full testing and homeowner declines for testing, verification and corrective action.

4.4 PROCEDURES FOR HVAC SYSTEM DESIGN AND INSTALLATION

The 1998 standards introduce new compliance credits that reward incremental improvements in the quality of duct system design, sealing and installation. Builders can choose to incorporate these improvements individually.

However, a truly quality duct system can not be assured without comprehensive attention to all aspects of duct design, sealing and installation, and performance testing of the system to verify that the system actually delivers comfort to all portions of the home in an energy efficient manner. Incremental improvement, for example through duct sealing alone, may fail to result in a well performing duct system.

The *Procedures For HVAC System Design and Installation* specified in Appendix K are intended to produce duct systems that are well designed, installed and performance tested to verify their effectiveness in delivering comfort and energy efficiency to home occupants. These procedures comprehensively address all aspects of quality installation of HVAC equipment and duct systems.

By following these procedures and the complementary compliance requirements, substantial compliance credit can be earned. Systems that meet the *Procedures For HVAC System Design and Installation* and meet compliance requirements would gain credit for the combination of reduced duct leakage, ACCA Manual D design, and possibly reduced duct surface area.

The Commission highly recommends that builders insure that all aspects of the *Procedures For HVAC System Design and Installation* given in Appendix K are followed, and take advantage of the combination of compliance credits that would result.